
CLAIMS

[Claim(s)]

[Claim 1] An infrared cut filter characterized by being the infrared cut filter characterized by providing the following, having a with a 400nm or more wavelength [550nm or less] transparency band and a with a 750nm or more wavelength [1050nm or less] non-penetrated band, and having a permeability property which permeability of a wavelength field inserted into said transparency band and said non-penetrated band dwindles from said transparency band side, applying to said non-penetrated band side A transparence substrate Multilayers to which two or more laminatings of the transparence thin film which consists of a transparence thin film which was formed on this transparence substrate, and which consists of a high refractive-index material, and a low refractive-index material were carried out by turns

[Claim 2] An infrared cut filter according to claim 1 characterized by permeability of said transparency band being 90% or more.

[Claim 3] Said multilayers are infrared cut filters according to claim 1 or 2 characterized by being the transparence thin film with which it is arranged by turns from said transparence substrate side in order of a transparence thin film which consists of said high refractive-index material, and a transparence thin film which consists of said low refractive-index material, and the last layer consists of said low refractive-index material.

[Claim 4] When setting design wave length to lambda, a layer of a transparence thin film which consists of said high refractive-index material A film is arranged for optical thickness from lambda/4 at said transparence substrate side, and a layer of lambda/4 or more thickness is arranged between a film and said last layer from the aforementioned lambda/4. For a layer of a transparence thin film which consists of said low refractive-index material, optical thickness is the infrared cut filter according to claim 3 characterized by arranging a film said transparence substrate side at said last layer, and arranging a layer of lambda/4 or more thickness between a film and said last layer from the aforementioned lambda/4 from lambda/4.

[Claim 5] An infrared cut filter according to claim 4 with which optical thickness is

characterized by preparing 0.3xlambda / four or more transparence thin films between said transparence substrates and said multilayers.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to the infrared cut filter which used optical multilayers.

[0002]

[Description of the Prior Art] With the image pick-up equipment containing color CCD series, such as an electronic "still" camera used for the video movie camera used for animation photography, or still picture photography, the infrared cut filter is arranged in the front face of color CCD series. This is for preventing that imaging will be carried out unlike the world which people regard as having said that the black wore red, when black is photoed [unlike the sensitivity of the eyes of human being who does not sense the light of long wave length from 700nm] to near the wavelength of 1100nm whose sensitivity of color CCD series is an infrared field for a certain reason. There are thickness, a glass type from which a permeability property changes with components, and the number of layers and the coating type from which a permeability property changes with optical thickness of the infrared cut filters used for the optical system of such solid state image sensor equipment.

[0003] A glass type infrared cut filter is a filter which consists of glass which penetrates a visible ray and absorbs infrared radiation, and the component which absorbs infrared radiation is the metal ion which melted into glass. As this metal ion, there is divalent iron ion, for example. In this case, iron exists in the condition trivalent [in glass / divalent and trivalent]. Trivalent iron ion has absorption in a light field from an ultraviolet-rays field, and presents yellow coloring. For this reason, when using iron, the large phosphate glass of a reduction operation on the glass used as the base is used, or in order to maintain the balance of iron ion, the reducing agent is added on glass. Moreover, various metals and the particle (for example, P2O5, AlF3 and aluminum 2O3, BaF2, BaO, NaF and CaO, SiO2 grade) of a compound are dissolved in others, and it is produced. Generally, the permeability of a glass type infrared cut filter is rapidly decreased near the boundary by the side of the short wavelength of a transparency band, as shown in drawing 7 , and it is gently decreased by the long wavelength side. Moreover, the permeability of a transparency band is about 90% at the maximum.

[0004] A coating type infrared cut filter is a filter which penetrates the light by optical multilayers and is made to reflect infrared radiation. This infrared cut filter carries out two or more laminatings of the transparence thin film which consists of low refractive-index materials

which consist of high refractive-index materials, such as a titanium dioxide, on transparence substrates, such as Xtal and white sheet glass, such as a transparence thin film and a silicon dioxide, by turns, and makes the light of the wavelength region for which it asks using interference of the light by the transparence thin film reflect or penetrate. For this reason, the refractive index, the thickness, and the number of laminatings of the transparence thin film which carries out a laminating are designed so that the light transmittance in each wavelength may be decided by optical thickness (product of the refractive index of a thin film, and the thickness of a thin film) of each transparence thin film which carries out a laminating by turns and the light of the wavelength region for which it asks may reflect or penetrate. In addition, generally, optical thickness is set as one fourth of design wave length so that the reflection factor or permeability of wavelength for which it asks may become max. The conventional coating type infrared cut filter has the permeability property which permeability decreases rapidly near the boundary by the side of the short wavelength of a transparency band, and long wavelength as shown in drawing 8 . Moreover, it is possible to make the permeability of a transparency band 90% or more.

[0005] By the way, in the video movie camera, the glass type infrared cut filter has been used conventionally. Since this has this type of permeability property close to the sensitivity property of human being's eyes, it is because the soft color reproduction nature near the world which can simplify color-balance adjustment of each signal of the red, green, and blue after photo electric conversion, and people look at is obtained. On the other hand, in the digital still camera, the coating type infrared cut filter has mainly been used. Since a laminating is carried out to the optical low pass filter which uses birefringence materials, such as Xtal, it can unite with it, the coating type which can perform generating prevention and an infrared cut of a Moire fringe to coincidence is thicker in itself and this can do an optical low pass filter thinly compared with a required glass type independently, it is because it is suitable for the digital still camera which has constraint in a space.

[0006]

[Problem(s) to be Solved by the Invention] Although the permeability property is used for the sensitivity property of human being's eyes by the solid state image sensor equipment of near many, a glass type infrared cut filter The permeability near [to make it penetrate / which it is thick and needs a space in the direction of an optical axis] 400-550nm with 90% or less [low] When changing a permeability property, since it is necessary to change thickness 0.4mm in order to shift 10nm of wavelength of 50% of permeability, the technical problem that complicated positioning of image sensor optical system may be needed occurs.

[0007] Moreover, the conventional coating type infrared cut filter has steep falling of permeability, and it has the technical problem that it becomes the image sensed sharper than the world which people look at while color-balance adjustment of each signal of the red, green, and blue after photo electric conversion becomes complicated, since it differs from the

sensitivity property of human being's eyes. the purpose of this invention -- the permeability of a transparency band with a wavelength of 400-550nm -- 90% or more -- it is -- the long wave of a transparency band -- it is offering the infrared cut filter as for which hardly changes thickness even if it changes the permeability property which permeability's decreases gently from a merit side to a non-penetrated band, but the space of the direction of an optical axis is made to the minimum.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, an invention-in-this-application person inquired about a coating type infrared cut filter. Consequently, since falling of permeability becomes steep so that a number of layers of multilayers increases in a coating type infrared cut filter, In a number of layers required to shade a 750-1050nm infrared field Reverse the conventional common sense that it was thought that permeability could not be attenuated gently, and with a matrix method using interference theory of an optical thin film It found out that optical thickness which a 750-1050nm infrared field is shaded [thickness], and attenuates permeability gently from a transparency field to a non-penetrated field was obtained.

[0009] An infrared cut filter concerning this invention was formed on a transparence substrate and this transparence substrate. A transparence thin film which consists of a transparence thin film which consists of a high refractive-index material, and a low refractive-index material consists of multilayers by which two or more laminatings were carried out by turns. It has a with a 400nm or more wavelength [550nm or less] transparency band and a with a 750nm or more wavelength [1050nm or less] non-penetrated band. It characterizes by having made it have a permeability property which permeability of a wavelength field inserted into a transparency band and a non-penetrated band dwindles from a transparency band side, applying to a non-penetrated band side. In this case, an example of 1 configuration of a permeability property is equipped with a transparency band which has 90% or more of permeability.

[0010] Moreover, an example of 1 configuration of multilayers mentioned above is arranged by turns from a transparence substrate side in order of a transparence thin film which consists of a high refractive-index material, and a transparence thin film which consists of a low refractive-index material, and is characterized by being the transparence thin film with which the last layer consists of a low refractive-index material. In this case, when setting design wave length to lambda, a film is arranged for optical thickness from lambda/4 at a transparence substrate side in a layer of a transparence thin film which consists of a high refractive-index material. A layer of lambda/4 or more thickness is arranged between a film and the last layer from lambda/4. An infrared cut filter with which a film has been arranged for optical thickness a transparence substrate side from lambda/4 at the last layer in a layer of a transparence thin film which consists of a low refractive-index material, and a layer of lambda/4 or more

thickness has been arranged between a film and the last layer from lambda/4 is offered. Moreover, as for an example of 1 configuration of an infrared cut filter mentioned abov , 0.3xlambda / four or more transparence thin films are prepared for optical thickness between a transparence substrate and multilayers.

[0011]

[Embodiment of the Invention] Drawing is used for below and the gestalt of implementation of this invention is explained to it. First, the gestalt of implementation of the 1st of this invention is explained. The mimetic diagram showing the configuration of the infrared cut filter whose drawing 1 is the gestalt of implementation of the 1st of this invention, and drawing 2 are the tables showing a presentation and optical thickness of the optical multilayers of this infrared cut filter.

[0012] As this infrared cut filter is shown in drawing 1 , two or more laminatings of the transparence thin film which consists of a transparence thin film which consists of a high refractive-index material 2 on the transparence substrate 1, and a low refractive-index material 3 are carried out by turns, and it counts from the transparence substrate 1 side, and the oddth layer is the high refractive-index materials 2, and the eventh layer consists of low refractive-index materials 3. Here, the dimensions of the transparence substrate 1 are 8.8mm wide, 8.2mm long, and Xtal with a thickness of 1.6mm. Moreover, the transparence thin film uses the silicon dioxide (SiO_2) for the high refractive-index material 2 at the titanium dioxide (TiO_2) and the low refractive-index material 3. The laminating of the titanium-dioxide thin film 2 and the silicon-dioxide thin film 3 is carried out from the transparence substrate 1 side to 38 layers by turns, and these transparence thin films form multilayers 4 so that it may become the optical thickness shown in drawing 2 .

[0013] Here, the layer of the titanium-dioxide thin film 2 whose number is odd counts the optical thickness of each class from the Xtal substrate, it is formed by the film even with the 9th layer thinner than lambda/4 from the 1st layer, and even the 37th layer is formed by lambda/4 or more thickness from the 11th layer. Moreover, in the layer of the silicon-dioxide thin film 3 whose number is even, similarly 38 layers which are the last layers even with the 6th layer are formed by thickness thinner than lambda/4 from a two-layer eye, and even the 36th layer is formed by lambda/4 or more thickness from the 8th layer. In addition, the value indicated by the optical thickness column of drawing 2 is expressed with the ratio at the time of setting lambda/4 [when setting the design wave length lambda to 755nm] of values to 1, and the product of this value and lambda/4 shows optical thickness.

[0014] Next, how to ask for the optical thickness shown in drawing 2 is explained using drawing 3 . Drawing 3 is explanatory drawing showing the multilayers by which the laminating was carried out on the substrate. Here, since it is easy, vertical incidence shall be carried out to the multilayer optical thin film system by which the light 5 of wavelength lambda was constituted from a material with which some differ, and a multiple echo shall arise on the

boundary of each class. In this case, the case where a phase shows a set and a coherency depending on the optical thickness of the class (especially wavelength) of light source and each class to be used arises, and it comes to interfere each other in a reflected light bunch. This is the basic principle of thin film layout. When the light of wavelength lambda makes vertical incidence the refractive index n vapor-deposited on the transparence substrate of a refractive index ns, and the non-absorbed homogeneous membrane of the physical thickness d, the optical property is expressed with the matrix of a formula (1).

[0015]

[Equation 1]

$$M = \begin{bmatrix} \cos\delta & \frac{i}{n}\sin\delta \\ i\,n\sin\delta & \cos\delta \end{bmatrix} = \begin{bmatrix} A & iB \\ iC & D \end{bmatrix} \cdots (1)$$

[0016] However, [0017]

[Equation 2]

[0018] This is called property matrix. A reflection factor R is expressed with a formula (3) at this time.

[0019]

[Equation 3]

[0020] When the property matrix of each class is Mk, Mk-1, --, M2 and M1 in the case of multilayers like drawing 3 , the optical property of multilayers is the product [0021] of each matrix.

[Equation 4]

[0022] It is come out and expressed. In a formula (3), if A=a, B=b, C=c, and D=d, the reflection factor of this k layer membrane can be found simply. In addition, using the actually used vacuum evaporation system, the refractive index n of a thin film conducted the measurement experiment of a refractive index, obtained the refractive-index dispersion formula by carrying out Sellmaier approximation of the value, and calculated the value over design wave length.

Thus, a formula (5) shows the obtained refractive index of a titanium dioxide, and a formula (6) shows the refractive index of a silicon dioxide.

[0023]

[Equation 5]

[0024]

[Equation 6]

[0025] In the infrared cut filter concerning the gestalt of implementation of the 1st of this invention Using these formulas, make the design wave length lambda to 755nm, and nd of Xtal and a formula (2) is made into the optical thickness of a thin film for a substrate. It has 90% or more of permeability in a 400-550nm wavelength field, and fell linearly from 90% or more whose permeability of 550-650nm is 550nm to 20 650nm% or less, and optical thickness from which the permeability of 750-1050nm becomes 1% or less was designed. In addition, it is not restricted to the optical thickness indicated to drawing 2 , and the optical thickness from which the above-mentioned permeability property is acquired can be changed in consideration of the ease of carrying out and manufacturing cost of manufacture.

[0026] Next, the manufacture method of this infrared cut filter is explained. To the Xtal substrate, this infrared cut filter carries out vacuum deposition of a titanium dioxide and the silicon dioxide by turns, and manufactures them. The manufacture method is as follows. First, while attaching a predetermined number in the installation fixture of the shape of a dome in which the Xtal substrate of the diameter of macrostomia was formed in the vacuum housing of a vacuum evaporation system, it puts into two electron beam evaporation sources in which the titanium dioxide and silicon dioxide of the shape of a pellet type or a grain were prepared in this vacuum housing separately, and a vacuum housing is exhausted.

[0027] If the pressure in a vacuum housing is set to 1x10 - 3 or less Pa, an electron beam is irradiated at an electron beam evaporation source, and a titanium dioxide and a silicon dioxide will be heated, respectively and will be evaporated. The shutter which can be opened and closed, respectively is prepared in right above [of two electron beam evaporation sources], the shutter by the side of a titanium dioxide is closed for the shutter by the side of a silicon dioxide at the time of vacuum evaporationo of closing and a silicon dioxide, the shutter by the side of a silicon dioxide is opened [the shutter by the side of a titanium dioxide is opened at the time of vacuum

evaporationo of a titanium dioxide,], and the laminating of the transparence thin film of a titanium dioxide and a silicon dioxide is carried out by turns on the Xtal substrate. In addition, since vacuum evaporationo will be promoted if an oxide is vapor-deposited in an oxygen ambient atmosphere, it vapor-deposits at the time of membrane formation of a titanium dioxide, supplying oxygen gas in a vacuum housing. While making an installation fixture rotate, moreover, exhausting a vacuum housing during membrane formation, is always continued.

[0028] The thickness of each transparence thin film is measured during vacuum evaporationo by the thickness monitor arranged right above [of opening prepared in the parietal region of an installation fixture], and as it closes a shutter by predetermined thickness, it is controlling thickness. If vapor-deposited to 38 layers, actuation of an electron beam evaporation source will be suspended, exhaust air of a vacuum housing will be stopped, and it will return to atmospheric pressure. In addition, as occasion demands, predetermined time heating of the Xtal substrate is carried out after vacuum evaporationo termination, crystallization of the vapor-deposited thin film is promoted and annealing processing which raises the film property of a thin film is performed. The Xtal substrate which vacuum evaporationo finished is cut by the predetermined dimension, and serves as each infrared cut filter. In addition, the manufacture method of this infrared cut filter is not restricted to the above-mentioned manufacture method.

[0029] Next, the permeability property of the infrared cut filter concerning the gestalt of implementation of the 1st of this invention is shown in drawing 4 . As shown in this drawing, the permeability property that permeability falls almost linearly at 90% or more by 400-550nm from 93% whose permeability is 550nm in 550-650nm to 17 650nm%, permeability makes asymptotic 0% by 650-750nm, and permeability becomes about 0% by 750-1050nm was acquired.

[0030] Next, the gestalt of implementation of the 2nd of this invention is explained. Drawing 5 shows the gestalt of operation of the 2nd of the infrared cut filter of this invention, and the same sign as drawing 1 shows the same portion in this drawing. The point that this infrared cut filter differs from what is shown in drawing 1 is having arranged one layer of transparence thin films 6 between the transparence substrate 1 and multilayers 4. Although a silicon dioxide or an aluminum oxide (aluminum 2O3) is used for this transparence thin film 6, even if it forms this transparence thin film 6, the configuration and permeability of the permeability curve which hardly changes to the case where the transparence thin film 6 is not added are obtained. In order that the optical thickness of this transparence thin film 6 may obtain the bond strength to the transparence substrate 1, since there is not almost 0.3xlambda / change of a permeability property by the difference in thickness although it is [four or more] required, the maximum of thickness is decided at least not with an optical property but with the ease of carrying out and manufacturing cost of manufacture. The manufacture method is the same as that of the gestalt of the 1st operation, and before it vapor-deposits multilayers 4, it does not

need a new manufacturing facility that what is necessary is just to add the production process which vapor-deposits the predetermined silicon dioxide or predetermined aluminum oxide of optical thickness.

[0031] The difference in the permeability property of the infrared cut filter of 39 layers which added this transparence thin film 6, and the infrared cut filter of 38 layers is shown in drawing 6 . In this drawing, that to which 7 used the aluminum oxide for the transparence thin film 6, the thing of 38 layers to which 8 does not add the transparence thin film 6, and 9 use a silicon dioxide for the transparence thin film 6. In addition, the optical thickness of a silicon dioxide and an aluminum oxide is 0.5xlambda/4, respectively. Drawing 6 shows that a required permeability property is acquired even if it is the case where one layer of transparence thin films 6 has been arranged between the transparence substrate 1 and multilayers 2. The infrared cut filter concerning the gestalt of this 2nd operation can exfoliate the whole film easily using a remover by arranging a silicon dioxide or an aluminum oxide between the transparence substrate 1 and multilayers 2. When a vacuum evaporationo activity goes wrong by this, it exfoliates and comes to be able to carry out film attachment of the whole film again. Thus, the film configuration of the gestalt of this 2nd operation has the feature of being more suitable for mass production.

[0032] In addition, although Xtal was used for the transparence substrate with the gestalt of implementation of this invention in order to make it unite with an optical low pass filter, it cannot be overemphasized that you may produce as an infrared cut filter simple substance using a glass substrate with a refractive index smaller than a titanium dioxide. Moreover, as long as it is the material which does not have absorption in a desired transparency band, materials other than a titanium dioxide, for example, zirconium oxide (ZrO_2) and zinc sulfide (ZnS), may be used as a high refractive-index material, and materials other than a silicon dioxide, for example, magnesium fluoride, (MgF_2) may be used as a low refractive-index material. In addition, both the stress of the combination of the high refractive-index material in the case of vapor-depositing to a plate substrate and a low refractive-index material produced in a thin film is small, or it is desirable for the value of stress to be [for a direction] the reverse sense soon.

[0033] Moreover, the dimension of the transparence substrate used for an infrared cut filter is decided according to the device used, and is not restricted to the dimension shown with the gestalt of this operation. Moreover, as a number of layers of multilayers, although the configuration of 38 layers and 39 layers was shown, if it is 34 or more layers, by changing a thin film material or vacuum evaporationo conditions, the refractive index of a transparence thin film will be changed and, according to this invention, it will be thought that the same permeability property can be acquired. In addition, the maximum of a number of layers has 45 or less desirable layers practically, although the ease of manufacturing, a manufacturing cost, etc. are decided by the reasons of manufacture.

[0034]

[Effect of the Invention] According to this invention, the infrared cut filter which has the permeability property of the same falling as the glass type infrared cut filter which was not in the conventional coating type infrared cut filter, and has the modification capacity of the thinness which is not obtained in the conventional glass type infrared cut filter, the improvement in permeability in a transmitted wave length field, and the permeability property hardly according to thickness is obtained. Moreover, since an infrared cut filter can be formed in the surface of an optical low pass filter, by the device using an optical low pass filter, the number of components can be reduced and space-saving-izing and cost reduction become possible.

[0035] Moreover, since the infrared cut filter by this invention can be manufactured by the same manufacturing installation as the conventional coating type infrared cut filter, the effect that initial-investment cost is unnecessary and is made cheaply is acquired. Thereby, in a video movie camera, the improvement in sensitivity, space-saving-izing, and cost reduction become possible, maintaining the conventional color reproduction nature. Moreover, in an electronic "still" camera, it is effective in the color reproduction nature more near appearance being obtained, maintaining space-saving [conventional] and low cost.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the mimetic diagram showing the example of 1 configuration of the infrared cut filter concerning the gestalt of operation of the 1st of this invention.

[Drawing 2] It is the table showing the thin film material in drawing 1 , and its optical thickness.

[Drawing 3] It is explanatory drawing showing the multilayers by which the laminating was carried out on the substrate.

[Drawing 4] It is the graph which shows the permeability property of the infrared cut filter of drawing 1 .

[Drawing 5] It is the mimetic diagram showing the example of 1 configuration of the infrared cut filter concerning the gestalt of operation of the 2nd of this invention.

[Drawing 6] It is the graph which compared the permeability property of the infrared cut filter of drawing 1 and drawing 5 .

[Drawing 7] It is the graph which shows the permeability property of the conventional glass type infrared cut filter.

[Drawing 8] It is the graph which shows the permeability property of the conventional coating type infrared cut filter.

[Description of Notations]

1 [-- Multilayers, 5 / -- The light of wavelength lambda, 6 / — A transparence thin film, 7 / — aluminum2O3 +38 layer multilayers, 8—38 layer multilayers 9 / — SiO2 +38 layer multilayers.] — A transparence substrate (Xtal substrate), 2 -- A high refractive-index material (titanium-dioxide thin film), 3 — A low refractive-index material (silicon-dioxide thin film), 4

[Translation done.]